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ORIGINAL PAPER

# Population distribution and threats to sustainable management of selected non-timber forest products in tropical lowland rainforests of south western Nigeria

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**Abstract:** Uncontrolled harvesting of non-timber forest products (NTFPs) poses a serious risk of extermination to several of these species in Nigeria. Yet, there is a paucity of information on the distribution, population status and sustainable management of NTFPs in most of the tropical lowland rainforests. We, therefore, assessed the population, distribution and threats to sustainable management of NTFPs within the tropical lowland rainforests of Omo and Shasha Forest Reserves, south western Nigeria. Data were obtained through inventory surveys on five top priority species including: bush mango (*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill), African walnut (*Tetracarpidium conophorum* (Mull. Arg.) Hutch. & Dalziel syn. *Plukenetia conophora*), chew-stick (*Massularia acuminata* (G. Don) Bullock), fever bark (*Annickia chlorantha* Setten & P.J.Maas syn. *Enantia chloranta*) and bush pepper (*Piper guineense* Schumach. & Thonn.). Purposive and stratified random sampling techniques were used for the inventory. Each forest reserve was stratified into three, *viz*: less disturbed natural forest (for areas that have been rested for at least ten years), recently disturbed natural forest (for areas that have suffered one form of human perturbation or the other in the last five years), and plantation forest (for areas carrying forest plantation). Data were collected from eighteen 10 m × 500 m belt transects located in the above strata. The species were generally fewer in both plantation and recently disturbed natural forest than the less disturbed natural forest, suggesting that forest disturbances (habitat modification) for other uses may have an effect on the occurrence and densities of the NTFPs. Exceptions to this trend were found for *P. guineense* and *T. conophorum*, which were fairly common in both plantation and recently disturbed natural forest. Among three tree NTFP species (i.e. *I. gabonensis*, *M. acuminata* and *A. chlorantha*), only *I. gabonensis* showed a significant difference in overall DBH size classes for both reserves ($t$=-2.404; $df$ =21; $p$=0.026). Three tree NTFP species in both reserves further showed differences from the regular patterns of distribution of trees. The fairly regular reverse J-shaped size class distribution observed for *M. acuminata* in the study sites, however, suggests a recuperating population. In general, destructive harvesting of species, logging operations, low population size, narrow distribution ranges and habitat degradation are the major threats to the population of NTFPs in the study area. The implications of our findings for sustainable management of NTFPs in the study area are discussed and recommendations are made for a feasible approach towards enhancing the status of the species.

**Keywords:** Tropical rainforest; non-timber forest products (NTFP); population density; distribution; forest management

## Introduction

The rainforests of south-western Nigeria have been identified as of high priority for conservation attention on a continental scale (Toham et al. 2006). Besides their roles in enhancing and maintaining environmental quality, they are also a reservoir of an enormous quantity of plant and animal communities that are vital for human existence. They support several forest user groups who depend on forest resources including timber and non-timber forest products (NTFPs) for their livelihood. They serve as veritable sources of food, fodder, medicines, building materials, dyes, flavorings and many other life-supporting biological requirements. In some cases, specific high value NTFP contributes a high share of the total income to both household and the regional economy (Yang et al. 2006; Jimoh and Haruna 2007).

Due to their ability to support and improve rural livelihoods while contributing to environmental stability and biodiversity conservation, NTFPs have attracted considerable interest as a basic component of sustainable development initiatives. However, large scale harvesting of NTFPs poses a serious threat of exter-

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mination to several popular species and certainly the continued supply of this group of products. For some products in the international market, export demand continued to stimulate increased pressure on their populations (Adekunle 1998). The management of NTFPs has been difficult to coordinate and harmonize due to poor knowledge of species in terms of utilization, biology and ecology. There is paucity of information on the distribution, population status and indigenous use pattern of NTFPs in most of the tropical lowland rainforests, particularly in Nigeria. Thus, deliberate integration of the role and potential of NTFPs in conservation and management planning remained weak. In Nigeria, the research and development efforts are not fully harnessed to address the issue of sustainable management and utilization of NTFPs (Bada and Popoola 2005; Jimoh and Adebisi 2005).

Past research and development efforts on NTFPs rarely considered setting up of inventory plots to generate data on the current population status nor did they address management issues related to these categories of forest products. To this effect, it is uncertain to guarantee the consistency of NTFPs contribution to rural livelihood and regional economy.

Assessments of NTFPs are of fundamental importance to forest management, providing information on the size distribution of key species on which harvesting plans can be developed. Before planning for effective management and exploitation of forest resources, forest managers need to know quantity and where the resources exist (Obua et al. 2000). Reliable data are also required in planning for economic investment in the NTFPs sector. In the light of the above, our study was carried out to assess the population distribution and threats to sustainable management of selected NTFPs within the tropical lowland rainforests of Omo and Shasha Forest Reserves, south western Nigeria.

## Materials and methods

### Study areas

The study was conducted in Omo and Shasha Forest Reserves, located within the tropical lowland rainforest zone of southwestern Nigeria. This zone covers about 2% of the total land area of Nigeria. It is also one of the most densely populated areas in Africa (White and Oates 1999). Within this zone, a number of studies (Sayer et al. 1992; FORMECU 1998) documented progressive shifts in the ecological boundaries of the tropical lowland rainforest as a result of human pressures. Therefore, the few relics of lowland rainforest zone of southwestern Nigeria is found mainly in protected areas, particularly the forest reserves in eastern Ogun, western Ondo and southern Osun States collectively referred to as Omo-Oluwa-Shasha complex (Fig. 1).

### Omo Forest Reserve

Omo Forest Reserve (OFR) is located in 6°35' N–7°05' N and 4°19' N–4°40' E. The Reserve covers about 130,500 ha forming common boundaries with Osun, Ago-Owu and Shasha Forest Reserves in Osun State and Oluwa Forest Reserve in Ondo State. It was legally gazetted a forest reserve through Order No. 10 Gazette No. 40 of 7th May 1925 which was amended in 1952 (Bada 1999). The rainy season in OFR usually commences in March with an annual mean of about 1,600 to 2,000 mm with two annual peaks in June and September. Temperature ranges from 32.15°C to 21.40°C and a minimum relative humidity of 76.34% (Isichei 1995). The vegetation of the Reserve is a mixed moist semi-deciduous rainforest. Large chunk of the forest were converted to *Gmelina arborea* monoculture in the early 80s. There are pockets of farming encroachments in several locations. Estimated total population in the area is between 20,000 and 25,000. Farming, fishing, hunting and NTFPs gathering are the predominant occupations for the majority of the enclaves' population.

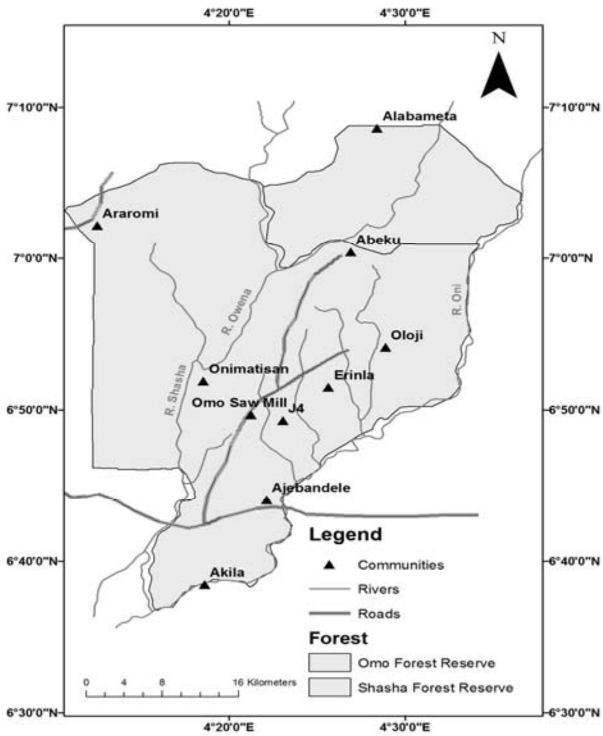


**Fig. 1 Map of Omo-Oluwa-Shasha Forest Reserves complex**

### Shasha Forest Reserve

Shasha Forest Reserve (SFR) is located in 7°00' N–7°30' N and 4°00' E–5° E. The reserve was first gazetted in 1925 as part of the Old Shasha Forest Reserve. The reserve shares boundaries with Omo Forest Reserve on the west. The northern and eastern boundaries are with Ife Native Authority Reserve and Oluwa Forest Reserve in Osun and Ondo States, respectively. The total area of the Reserve is currently 23,064 ha. About 1,523 ha are under plantation of various species such as *Gmelina arborea*, *Tectona grandis*, *Terminalia spp*, *Pinus spp and Nauclea diderichii*. The remaining 21,541 ha is currently dominated by pockets of degraded natural forests characterized with broken canopy (Jimoh 2002). The rainy season in SFR usually commences from March/April and lasts till November. Total Annual rainfall ranges from 887 mm to 2,180 mm. The mean annual

temperature is about 26.5°C with annual range of 19.5°C–32.5°C.

The reserve is subdivided into two major areas, *viz*, Areas 4 and 5. There are about 40 communities within and around the forest reserve. The population of these communities range from 200 to 2,000 inhabitants.

Data collection and sampling procedure

Data were obtained through ecological inventory. To assess the population densities of non-timber forest products within the forest reserves, five top priority species were selected including bush mango (*I. gabonensis*), African walnut (*T. conophorum syn. P. conophora*), chew-stick (*M. acuminata*), fever bark (*A. chlorantha*) (*syn. Enantia chloranta*) and bush pepper (*P. guineense*; Table 1) based on the results of NTFPs ranking and prioritization exercise in the study area. Purposive and stratified random sampling techniques were used for the inventory of the selected NTFPs. This was based on the fact that most NTFPs are often difficult to locate in the forest without prior acquaintance with the area. Some usually have low densities and are often aggregated within definite sites (Peters 1994). Therefore, the study relied on the outcome of a reconnaissance survey and the guidance of forest guards and local harvesters of NTFPs who are conversant with the study area, to locate sites where each of the selected species occurred. Each forest reserve was stratified into three belts, *viz*, less disturbed natural forest (for areas rested for at least ten years), recently disturbed natural forest (for areas which have suffered one form of human perturbation or the other in the last five years) and plantation forest (for areas carrying forest plantation). Following a tested methodology for NTFPs assessment (Hall and Bawa 1993; Sunderland and Tchouto 1999; Siebert 2004), the inventory of NTFPs consisted of a series of temporary, parallel, 10 m-wide belt transects established along a baseline. In each stratum (as defined above), three belt transects of 500 m × 10 m were laid along a predefined compass bearing. Enumeration was done carefully along the belt transect within 5 m on either side of the central line for all individuals of the five species selected for the inventory. The 5-m distance was constantly checked with a tape measure for individuals considered to be on borderline. A total of nine transects were inventoried for each species in each reserve. The proportion of the total area in the forest reserve is 0.010% and 0.059% for OFR and SFR, respectively. Both forest guards and local guides were involved in the identification of the desired taxa. Information includes species height, diameter at breast height (DBH) and the total number of individual stems. For each species, a 1.5-ha area was sampled in each stratum (i.e. less disturbed natural forest, recently disturbed natural forest and plantation forest) for each of the two reserves. Data collected were used for estimating the distribution, density and size structure of selected NTFPs.

**Table 1: Species selected for the study and commercial potentials**

| Species | Life form | Part harvested | Appreciation by local population | Use | Use frequency | Commercial potential of species |
|---|---|---|---|---|---|---|
| *I. gabonensis* (Aubry-Lecomte ex O'Rorke) Baill | canopy-emergent tree | fruits, seeds, kernel | medium to high | food condiment soup thickener | medium to high | high |
| *T. conophorum* (Mull.Arg.) Hutch. & Dalziel (syn. *Plukenetia conophora*) | woody liana (climber) | Fruits | medium to high | food snack | high | high |
| *M. acuminata* (G Don) Bullock (*Rubiaceae*) | under storey tree | Stem | high | chew-stick | high | high |
| *A. chlorantha* (Oliv.) Setten & P.J.Maas (syn. *Enantia chloranta*) | under storey Tree | Bark | high | medicinal | high | high |
| *P. guineense* (Schum. & Thonn.) | non woody liana (climber) | leaves and Seeds | high | condiment leafy vegetable | high | high |

Data analysis

The data generated from the survey were subjected to descriptive statistics using frequency distribution tables and histograms. Computations were conducted to estimate the number of species per hectare for each of the selected species. Analysis of variance (ANOVA) was used to test for differences in the number and distributions of selected species by forest type in the study areas. ANOVA was also used to test for differences in DBH and height distributions of selected species by forest type. The Independent Samples test was further used to compare the above-mentioned parameters (i.e. DBH and height) for both reserves. All data were carried out using the Statistical Package for Social Sciences (SPSS 15.0 Evaluation 2006).

## Results

Distribution, density and size classes of the selected NTFP species

*Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill*

Density of bush mango (*I. gabonensis*) was low in all forest types (less disturbed natural forest, recently disturbed natural forest and plantation forest). These range from 3.33/ha in less disturbed natural forest to 2.67/ha in plantation area and 2.00/ha in recently disturbed natural forest in Shasha Forest Reserve. In Omo Forest Reserve, the estimates range from 3.33/ha in less disturbed natural forest to 2.00/ha in recently disturbed natural forest and 2.00/ha in plantation area (Table 2). Mean densities of the species for all sites

in the two reserves compared very closely ($F$ = 4.000, $df$ = 8, $p$= 0.079 (OFR); $F$ = 1.500, $df$ = 8, $p$= 2.96 (SFR)). There is also no significant difference in DBH size classes between sites in OFR ($F$ = 0.142, $df$ = 10, $p$= 0.870). On the contrary, there is a significant difference in dbh size classes between sites in SFR (F = 55.129, $df$ =11, $p$< 0.05). The size-class distribution exhibited by *I. gabonensis* in both Omo and Shasha Forest Reserves suggests poor recruitments for the species in both reserves (Fig. 2). No stand of *I. gabonensis* was encountered in the class of < 20cm diameter in both Omo and Shasha Forest Reserves. More stands of the species were represented in the 31–40 cm diameter class in Shasha Forest Reserve, while stands in the 41–50 cm class were predominant in Omo Forest Reserve. Similarly, only in Omo Forest Reserve were their stands exceeding the 50 cm DBH class. There are no large trees which should normally serve as seed trees in Shasha Forest Reserve. Height distribution of *I. gabonensis* by forest type in OFR also shows no significant difference ($F$ = 0.003; $df$ = 10, $p$ = 0.997). In contrast, there is a significant difference in height distribution of *I. gabonensis* by forest type in SFR ($F$ = 16.655; $df$ = 11, $p$ < 0.05). The independent samples test used to compare the DBH of *I. gabonensis* from both reserves shows a significant difference in DBH distribution ($t$ = -2.404; $df$ = 21; $p$ = 0.026; Fig. 2). Although, more individuals occurred in the 30.0 – 39.9 m height class in Shasha Forest Reserve, while individuals in the 40.0 – 49.9 m height class were predominant in Omo Forest Reserve (Fig. 3), there is no significant difference in overall height distribution of *I. gabonensis* for both reserves ($t$ = 4.543; $df$ = 21; $p$ < 0.05). Observations on height and size class distributions of *I. gabonensis* in Omo and Shasha Forest Reserves follow similar patterns.

**Table 2. Current status of *Irvingia gabonensis* in Shasha and Omo forest reserves, Southwestern Nigeria**

| Site | Shasha Forest Reserve | | | Omo Forest Reserve | | |
|---|---|---|---|---|---|---|
| | Total number of individuals | Mean number of individuals per hectare | Mean DBH (cm) | Total number of individuals | Mean number of individuals per hectare | Mean DBH (cm) |
| Plantation area | 4 | 2.67 | 28.20 | 3 | 2.00 | 41.63 |
| Natural forest [1] | 5 | 3.33 | 37.36 | 5 | 3.33 | 41.60 |
| Natural forest [2] | 3 | 2.00 | 33.47 | 3 | 2.00 | 38.47 |
| Mean (All sites) | 4 | 2.67 | 33.01 | 3.67 | 2.44 | 40.57 |

[1] Rested for at least ten years; [2] Disturbed since the past five years and above.

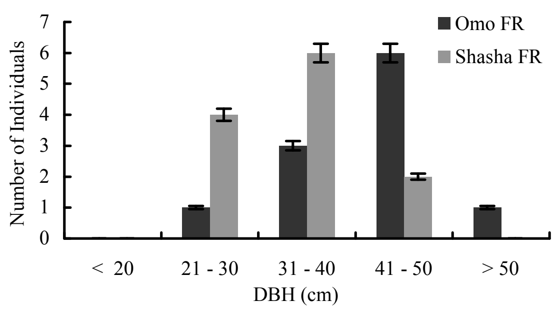


**Fig. 2 Size distribution of *Irvingia gabonensis* in Omo and Shasha forest reserves**

*T. conophorum (Mull. Arg.) Hutch. & Dalziel (syn. P. conophora)*
*T. conophorum* was fairly prevalent in all forest types sampled in both Omo and Shasha Forest Reserves. More stands of the species were found in the plantation area in OFR. Analysis of variance for differences in the density and distribution of *T. conophorum* by forest type, however, shows no significant difference in both OFR and SFR ($F$ = 3.211, $df$ = 8, $p$= 0.113 (OFR); $F$ = 10.111, $df$ = 8, $p$= 0.12 (SFR)). Mean densities for the species range from 14.67/ha in less disturbed natural forest to 10.67/ha in plantation area and 7.33/ha in recently disturbed natural forest in Shasha Forest Reserve. In Omo Forest Reserve, estimates range from 16.00/ha in plantation area to 14.67/ha in less disturbed natural forest and 5.33/ha in recently disturbed natural forest (Table 3). *T. conophorum* seems to be well adapted in all the forest types and also grows in association with taller trees.

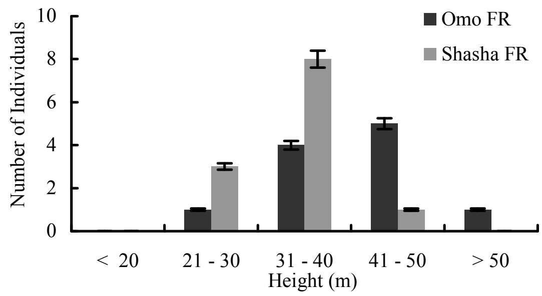


**Fig. 3 Height-class distribution of *Irvingia gabonensis* in Omo and Shasha forest reserves**

**Table 3. Current status of *Tetracarpidium conophorum* in Shasha and Omo forest reserves, Southwestern Nigeria**

| Site | Shasha Forest Reserve | | Omo Forest Reserve | |
|---|---|---|---|---|
| | Total number of individuals | Mean number of individuals per hectare | Total number of individuals | Mean number of individuals per hectare |
| Plantation Area | 16 | 10.67 | 24 | 16 |
| Natural Forest[1] | 22 | 14.67 | 22 | 14.67 |
| Natural Forest[2] | 11 | 7.33 | 8 | 5.33 |
| Mean (all sites) | 16.33 | 10.89 | 18 | 12 |

[1] Rested for at least ten years; [2] Disturbed since the past five years and above.

*Massularia acuminata (G. Don) Bullock (Rubiaceae)*
*M. acuminata*, locally known as *pako ijebu*, is commonly exploited as chew-stick. Mean densities range from 14.00/ha in recently disturbed natural forest to 12.67/ha in less disturbed natural forest and 6.67/ha in plantation area in Shasha Forest Reserve. In Omo Forest Reserve, estimates range from 18.00/ha in less disturbed natural forest to 15.33/ha in recently disturbed natural forest and 6.00/ha in plantation area (Table 4). There is significant difference in mean densities of the species between sites in OFR ($F$ = 10.720, $df$ = 8, $p$= 0.010 (OFR)). Contrarily, there is no significant difference in mean densities of the species between sites in SFR ($F$ = 2.943, $df$ = 8, $p$ < 0.129 (SFR)). The occurrence of the species in the plantation area in both Omo and Shasha Forest Reserves was very scanty. There is a significant difference in DBH size classes across sites in both forest reserves

($F = 19.684$, $df = 58$, $p < 0.000$ (OFR), $F = 7.117$, $df = 49$, $p = 0.002$ (SFR)). More species were found in the 5.1 – 10.0cm class (Fig. 4a). Also, height distribution of *M. acuminata* by forest type in OFR shows significant difference ($F = 17.585$; $df = 58$, $p < 0.05$). In contrast, there is no significant difference in height distribution of *M. acuminata* by forest type in SFR ($F = 2.665$; $df = 49$, $p = 0.080$). However, the 5–9.99 m class was predominant in both reserves (Fig. 4b). The Independent Samples test used to compare the DBH of *M. acuminata* for both reserves shows no significant difference in DBH distribution ($t = -637$; $df = 107$; $p = 0.526$; Fig. 4a). There is also no significant difference in overall height distribution of *M. acuminata* for both reserves ($t = 0.948$; $df = 107$; $p = 0.345$; Fig. 4b). Since *M. acuminata* is harvested for its stem, observation on species size and height distributions are consistent with apriority expectation as the product supplies the commonest-used chew-sticks in Nigeria, and it's heavily exploited. The fairly regular reverse J-shaped size class distribution observed for *M. acuminata* in the study sites also suggests a recuperating population and one that possibly has a good habitat to regenerate save for the negative impact of logging activities in the area.

**Table 4. Current Status of *Massularia acuminata* in Shasha and Omo forest reserves, Southwestern Nigeria**

| Site | Shasha Forest Reserve: Total number of individuals | Shasha Forest Reserve: Mean number of individuals per hectare | Shasha Forest Reserve: Mean DBH (cm) | Omo Forest Reserve: Total number of individuals | Omo Forest Reserve: Mean number of individuals per hectare | Omo Forest Reserve: Mean DBH (cm) |
|---|---|---|---|---|---|---|
| Plantation area | 10 | 6.67 | 9.18 | 9 | 6 | 10.30 |
| Natural forest [1] | 19 | 12.67 | 8.78 | 27 | 18 | 7.93 |
| Natural forest [2] | 21 | 14 | 5.74 | 23 | 15.33 | 5.13 |
| Mean (All sites) | 16.67 | 18.17 | 7.90 | 39.33 | 26.22 | 7.79 |

[1] Rested for at least ten years；[2] Disturbed since the past five years and above.

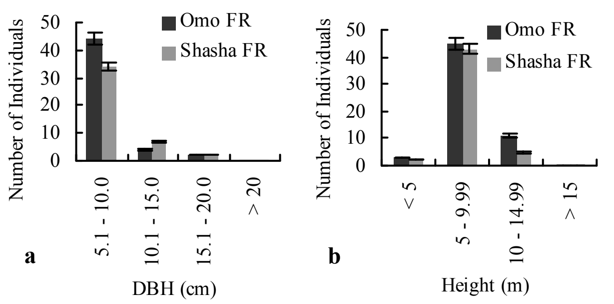


**Fig. 4 DBH (a) and height class (b) distribution of *Massularia acuminata* in Omo and Shasha forest reserves**

*Annickia chlorantha (oliv.) Setten & P.J.Maas (syn. Enantia chloranta)*

For *A. chlorantha*, mean densities range from 24.67/ha in less disturbed natural forest to 17.33/ha in recently disturbed natural forest and 13.33/ha in plantation area in Shasha Forest Reserve. In Omo Forest Reserve, estimates range from 19.33/ha in less disturbed natural forest to 19.33/ha in plantation area and 16.00/ha in recently disturbed natural forest (Table 5). There is no significant difference in mean densities of the species between sites in both OFR and SFR ($F = 0.291$; $df = 8$; $p = 0.758$ (OFR), $F = 1.549$, $df = 8$, $p = 0.287$ (SFR)). More stands of the species were, however, found in the less disturbed natural forest area in both reserves. Similarly, there is no significant difference between DBH size classes and sites in OFR ($F = 0.300$; $df = 81$; $p = 0.741$). However, there is significant difference in DBH size classes between sites in SFR ($F = 52.488$, $df = 82$, $p = 0.0.05$; Fig. 5). Dbh size classes were higher in the plantation area in the reserve (i.e. SFR) than that in other sites within the reserve. Nevertheless, more stands of the species were represented in the 5.1–10 cm diameter class in both Omo and Shasha Forest Reserves. Only in Shasha Forest Reserve were their stands exceeding the 15.1–20 cm size class. Height distribution of *A. chlorantha* by forest type shows no significant difference ($F = 0.317$; $df = 81$, $p = 0.729$) in OFR. In contrast, there is a significant difference in height distribution of *A. chlorantha* by forest type in SFR ($F = 33.957$; $df = 74$, $p < 0.05$). Height distribution was also higher in the plantation area than in other sites, an observation similar to the pattern obtained for the DBH size classes. Height distribution further shows that stand of *A. chlorantha* occur in higher classes in SFR than those in OFR. The Independent Samples test used to compare the DBH of *A. chlorantha* for both reserves shows significant difference in DBH distribution ($t = -7.625$; $df = 163$; $p < 0.05$; Fig. 5. In terms of height distribution, most trees occurred in the 5.0–14.9 m height class in Shasha Forest Reserve, while more individuals were found in the 5.0 – 9.9 m height class in Omo Forest Reserve. On the whole, there is significant difference in overall height distribution of *A. chlorantha* for both reserves ($t = -6.754$; $df = 163$; $p < 0.05$; Fig. 6).

**Table 5. Current status of *Annickia chlorantha* in Shasha and Omo forest reserves, Southwestern Nigeria**

| Site | Shasha Forest Reserve: Total number of individuals | Shasha Forest Reserve: Mean number of individuals per hectare | Shasha Forest Reserve: Mean DBH (cm) | Omo Forest Reserve: Total number of individuals | Omo Forest Reserve: Mean number of individuals per hectare | Omo Forest Reserve: Mean DBH (cm) |
|---|---|---|---|---|---|---|
| Plantation area | 20 | 13.33 | 15.71 | 29 | 19.33 | 6.72 |
| Natural forest [1] | 37 | 24.67 | 11.14 | 29 | 19.33 | 6.53 |
| Natural forest [2] | 26 | 17.33 | 6.32 | 24 | 16 | 6.34 |
| Mean (All sites) | 27.67 | 18.44 | 11.06 | 27.33 | 18.22 | 6.53 |

[1] Rested for at least ten years；[2] Disturbed since the past five years and above.

*Piper guineense (Schum. & Thonn.)*

*P. guineense* is more abundant in OFR than SFR. They are more prevalent in the plantation areas in both reserves. Mean densities for the species range from 46.00/ha in plantation area to 36.00/ha in less disturbed natural forest and 26.67/ha in recently disturbed natural forest in Shasha Forest Reserve. In Omo Forest Reserve, estimates range from 110.67/ha in plantation area to 92.67/ha in less disturbed natural forest and 61.33/ha in recently disturbed natural forest (Table 6). There is no significant difference in mean densities of the species for all sites in OFR ($F = 1.848$; $df = 8$; $p=$

0.237). Contrastingly, there is significant difference in mean densities of the species among sites in SFR ($F$ = 7.424; $df$ = 8; $p$= 0.024). The pattern of occurrence of the species in both reserves compared relatively closely with what was obtained for *T. conophorum*. The species also appears to show high adaptability to all the forest type.

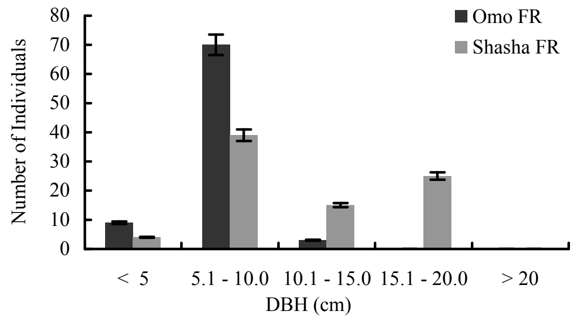


**Fig. 5 Size distribution of *Annickia chlorantha* in Omo and Shasha forest reserves**

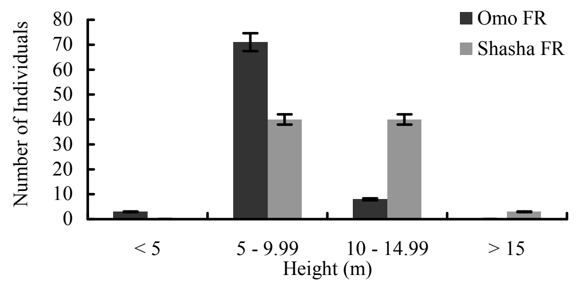


**Fig. 6 Height-class distribution of *Annickia chlorantha* in Omo and Shasha forest reserves**

**Table 6. Current Status of *Piper guineense* at Shasha and Omo forest feserves, Southwestern Nigeria**

| Site | Shasha Forest Reserve | | Omo Forest Reserve | |
|---|---|---|---|---|
| | Total number of individuals | Mean number of individuals per hectare | Total number of individuals | Mean number of individuals per hectare |
| Plantation Area | 69 | 46 | 166 | 110.67 |
| Natural Forest[1] | 54 | 36 | 139 | 92.67 |
| Natural Forest[2] | 40 | 26.67 | 92 | 61.33 |
| Mean (all sites) | 108.67 | 72.44 | 132.33 | 88.22 |

[1] Rested for at least ten years; [2] Disturbed since the past five years and above.

## Discussion

There are indications that all the selected species in our study are heavily exploited. Their low density, rarity and occurrence in patches within the forest landscape may suggest that they are locally vulnerable. This observation is supported by Ojo (2004), who carried out an assessment of sixteen permanent sample plots at Abeku sector of Omo Forest Reserve, reporting only one stand of *A. chlorantha* for the year 2000 enumeration as against thirteen stands in 1985. Within the same study site, no individual of *I. gabonensis* was recorded for the year 2000, whereas four were enumerated in 1985. Similarly, Adekunle (2006) in a study of tree species diversity in tropical rainforest ecosystem (including Shasha, Omo and Ala Forest Reserves) of south-west Nigeria reported a population density of 1.00/ha for *I. gabonensis* in both Shasha and Ala Forest Reserves. He recorded no stand of the species in the Omo Forest Reserve. Adekunle (2006) encountered no stand of *M. acuminata* in three study sites. In the same vein, Aderounmu et al. (2002) submitted that *M. acuminata* is almost extinct in part of Nigeria rainforests and is already being imported from other West African countries. This is also the opinion of some forestry personnel in Omo Forest Reserve with the view that the species is already exterminated in the forest. Conversely, our study confirms the prevalence of *M. acuminata* at the study sites. The disparity between the values obtained in this study and other works (e.g. Adekunle 2006) could be attributed to the clump distributive nature of the three tree species (i.e. *I. gabonensis, M. acuminata* and *A. chlorantha*) as well as differences in sampling methods.

As shown in Fig. 3, there are no young trees of *I. gabonensis* in the study area, which is an indication of threat to continued existence of the species. Sunderland et al. (2003) attributed irregularities in recruitment nature of *I. gabonensis* to the tendency of the species to mast, and more likely to long-term harvesting of their fruits and seeds. Meanwhile, *I. gabonensis*, *T. conophorum*, *M. acuminata* (except Shasha Forest Reserve), *A. chlorantha* and *P. guineense* were found to be consistently fewer in recently disturbed natural forest than in the less disturbed natural forest, suggesting that forest disturbances (habitat modification) for other uses may constitute a threat to the regeneration of the NTFPs. Apart from excessive harvesting that currently pervades the exploitation of the species in the former habitat, timber harvesting techniques and operations within the forest reserves have been destructive to non-targeted flora and fauna species.

The same trend described above is evident in species abundance of *I. gabonensis*, *M. acuminata* and *A. chlorantha* in the less disturbed natural forest as against the plantation forest. However, *P. guineense and T. conophorum* showed a contrasting feature in terms of abundance in the two habitats. This observation corroborates the report of Jimoh (2002) on abundance and distribution of *P. guineense* in Shasha Forest Reserve. The incidence of taller tree species as support seems to be significant to the prevalence of these categories of NTFPs as they are both climbers which use taller trees as support to reach out for sunlight.

Meanwhile, among three tree NTFP species (*I. gabonensis*, *M. acuminata* and *A. chlorantha*), only *I. gabonensis* showed a significant difference in DBH size classes within sites for both reserves. Still, all the tree NTFP species in both reserves showed patterns that differ from the regular patterns of distribution of trees. For *M. acuminata*, however, there were a number of individuals in the lower size class (very young), while the larger class diameter stands were extremely scanty. The points to the impact of excessive exploitation of the older trees which would normally serve as mother trees have a long-term effect on the population. This also

constitutes a serious threat to the sustainability of the species.

In terms of height-classes distribution, both *A. chlorantha* and *M. acuminata* have the greatest proportion of trees encountered in the lower stratum. The older and taller trees might also have been exploited with serious implications for seed supplies for species regeneration. This again portends great threat to the sustainability of the species. The findings on *A. chlorantha* and *M. acuminata* in terms of DBH size and height distributions are consistent with apriority expectation since both species are under serious pressures of exploitation for their stem and bark, respectively. It shows clearly that the older trees of both species must have been killed through destructive harvesting. The implication of this is that natural regeneration of the two species in the study area may be difficult since matured mother plants that would produce seeds are very few or non existent. Apart from this, *A. chlorantha* trees cannot recover if the bark is removed over a large surface around the stem. Field observations, in general, revealed that destructive harvesting of species, logging operations, low population size, narrow distribution ranges and habitat degradation are the major threats to sustainable management of NTFPs in the study area.

The abundance, spatial and size class distributions of species are important parameters to assess the sustainability of extracted species. While most of the selected species in our study occur in low densities and in patches within the forest landscape, the higher densities of some of the study NTFPs (such as *T. conophorum* and *P. guineense*) in certain forest habitats suggest that different forest types may merit special attention for future management of NTFPs in the area. Generally, low density resources are usually difficult for collectors to locate, they require lengthy travel times, produce a low-yield per unit area, and they are extremely susceptible to over-exploitation (Peters 1994).

In the intervening time, therefore, systematic attempt could be made to map NTFPs in the area, so that forest managers know the resources location and quantity. Researching and implementing silvicultural practices such as increased light levels on given species in forests managed for NTFPs is another important prospect. Silvicultural treatments such as climber cutting or undergrowth removal to encourage regeneration of commercial timber species may have to be compromised to enhance production of certain NTFPs, particularly the climbers and understory species such as *T. conophorum*, *P. guineense* and *M. acuminata* in areas where they are concentrated. Enrichment planting and the pegging of harvesting regimes and cycles are other approaches that could be adopted for sustainability of NTFPs extraction in the study area. Even though the compatibility of timber and NTFP harvesting is a contentious one, the application of Reduced Impact Logging (RIL) guidelines to minimize unintended damage to NTFP species during timber extraction should also be adopted. Destructive harvesting of species should be mitigated through enforced regulations. Furthermore, since there is a burgeoning of information on silvicultural techniques for the development and conservation of a number of the study species (such as *I. gabonensis* (Ladipo et al. 1996; Atangana et al. 2000 and 2002); *M. acuminata* (Oni and Ojo 2002) and *A. chlorantha* (Gbadamosi and Oni 2005), it should not be difficult to integrate these species into the local farming systems. The domestication of NTFPs and their cultivation in multi-strata agroforestry systems could be a means to also reduce the pressure on forests. Cunningham and Mbenkum (1993) and Stewart (2003) have noted that for *Prunus africana* in Cameroon, the establishment of its plantations was not only a means for *ex situ* conservation of threatened harvested plants, but also as a way of reducing the harvesting pressure on wild natural populations from which the bulk of the medicinal products are harvested. Plantation establishment for high value NTFP species should, however, be done on marginal lands to avoid mistakes of the past where natural forests were cleared and converted to monoculture plantations.

## Conclusion

The integration of non-timber forest products is not widely addressed in forest management plans in this part of the world. While the tropical rainforest provides a vast array of products that are relevant to the livelihood of several millions of people, the key for deriving sustainable benefit from the NTFPs is the reconciliation of biological sustainability with commercial viability. If the prevalence and availability of NTFP species is particularly threatened by logging operation and destructive extraction methods, forest managers should strive to strictly enforce all existing forest laws and edicts, and arrest and prosecute illegal exploiters of forest resources to serve as deterrent to others. There is a major need to reconcile timber harvesting with NTFPs extraction. NTFPs extraction should be well organized and coordinated with harvest guidelines for the sustainability of extraction. A key feature of a successful approach to NTFP management will be a sound monitoring and evaluation program. This must also include strong institutional support in form of incentives for forest dwellers and traders in NTFPs. Future forest management plans should include guidelines for incorporating the management of non timber forest products.

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